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Lewis Research Center



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A New Low-Cost Method for Producing Collimating Mirrors

The problem:

To reduce the cost of fabricating collimating mirrors while retaining or improving their optical accuracy. Conventional procedures for attaining highly specular reflective surfaces involve plating the machined surfaces with hard electroless nickel and optically polishing the plated surfaces. However, plating and polishing the machined surfaces by the conventional techniques is relatively expensive because optical standards are subjective and the hard nickel plating is difficult to work with.

The solution:

A new method for finishing and plating the machined mirror surfaces in which surface tolerances are consistently held within the accepted limits of ± 0.0076 mm (± 0.0003 inch) and by which the cost is reduced to less than one-tenth that of conventional techniques.

How it's done:

In this method, the mirror blanks are machined to the desired radius by conventional but careful techniques producing a surface with ± 0.0076 mm (± 0.0003 inch) tolerance and a 16 RMS finish. Polishing further improves the machined contours and surfaces. The polished surfaces are flowcoated with a very thin uniform coating of resin and cured to provide a hard, thermally stable glossy surface. The resin-coated surfaces are then vacuum-coated with pure aluminum to provide highly reflective specularly, and overcoated with silicon monoxide to provide a hard protective finish.

This method was developed and used for fabricating two collimating mirrors, each 4.88 by 9.75 m (16 by 32 feet), to be used in a space solar simulator. Together, the two collimating mirrors were made up of 75 hexagonal panels, each 1.40 m (55 inches) across the flats, with half-hexagonal panels around the periphery.

The solar simulator mirror panels were fabricated from discs of 5083-0 aluminum, 1.63 m (64 inches) in

diameter and 3.81 cm (1.50 inches) thick. The front and back surfaces of the discs were machined flat and parallel. The discs were held with minimum pressure, and light cuts were made alternately on the front and the back. The faces of the discs were then milled to the required spherical contour and to a tolerance of ± 0.0076 mm (± 0.0003 inch) with a 16 RMS finish. The contoured faces were polished, using a specially-built polishing table and head, to the maximum specularly attainable on aluminum, and the contour tolerance improved to ± 0.0051 mm (± 0.0002 inch). At this point in the process, the polished faces were masked with heavy paper for protection and the discs trimmed to the desired hexagonal shape.

Since soft aluminum cannot be polished to a high specularly, a highly reflective coating was required. The aluminum surfaces can be polished to acceptable surface contour tolerances, but the polished surfaces exhibit an "orange peel" effect and some grain boundary pull-up. Although such surfaces are not suitable for aluminizing applied directly, it was found that aluminizing can be satisfactorily applied over a very thin uniform coating of resin. Spray coatings of resin were not satisfactory; suitably uniform thicknesses could not be attained, and spray coatings increased the surface contour errors by approximately 0.013 mm (± 0.0005 inch). Therefore, a flow-coating technique was developed. It is at this step in the mirror fabrication cycle where the greatest cost savings are derived. The hexagonal mirror panels were placed vertically in a leak-tight tank, the tank was filled with alkyd-melamine resin, and the resin drained from the tank at a carefully controlled rate. Best results were obtained when the rate of fall of the liquid was 2.5 cm (one inch) per minute. The mirror panels were removed from the coating tank, fitted with dust covers, and the coating was cured on a heated table at 149°C (300°F). The resin-coated mirror panels were then placed in a vacuum chamber and vacuum-deposition-coated with a

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1000-angstrom thickness of pure aluminum. Without breaking the vacuum, the panels were moved to another part of the vacuum chamber and vacuum-deposition-coated with a 500-angstrom thickness of silicon monoxide.

Notes:

1. Price estimates for finishing and plating the machined surfaces of these panels by conventional techniques were in the range of \$3000 per panel. The cost of finishing and plating by the new method developed was less than \$300 per panel.
2. The collimating mirror panels produced by this method have an accuracy averaging approximately one-half minute of angle, well within the one to two-minute accuracy specified.

3. No further documentation is available. Specific questions, however, may be directed to:

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Patent status:

NASA has decided not to apply for a patent.

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